A framework to improve trust in Agent-Based Models of Human-Environment Interactions

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Abstract. Agent-Based Modelling (ABM) and simulation have gained popularity in disciplines dealing with complex systems, such as urban systems. Despite the increasing number of models built by experts and users, it is not always guaranteed that one is able to replicate the basic results of a research model nor to understand it. In this paper, we raise the questions that need to be answered in order to cope with ABM specification issues. We review some of the existing solutions that have been developed. We aim to address this problem by building a framework that includes a domain specific modelling language to respond to ABM documentation concerns. We show that ideas from the Web Semantic can enhance the understanding of ABM and improve users' trust in this kind of tools.

Keywords: Domain ontology · Geographic Information Science · Agent-Based Modelling · Domain Specific Modelling Language.

1 Introduction: Why documenting ABM matters

To understand geographical problems such as sprawl, congestion and segregation, researchers have begun to focus on agent-based modelling (ABM) which allows one to simulate the individual actions of diverse agents, and to measure the resulting system behaviour and outcomes over time [5]. Modellers have been using ABM to simulate social interactions to understand and manage cities and urban infrastructure systems. [1], [2] and [3] are a few examples of a broad range of applications.

As the number of models created by researchers increases, the opportunity to analyse a model and replicate its results naturally grows. Modellers are seeking to transfer the knowledge from one domain to another domain or to replicate an ABM and adapt it to their own case studies. It turns out that comparing different models representing a same empirical fact is a difficult task. In order to comprehend a model and assess the results of its simulation, this models needs to be clearly described. This description is necessary to enhance communication, replication and comparison of models but also to enable dialogue among disciplines [7].

2 Related Work

For the last decade, initiative have been developed to enhance the description and communication of ABM. The ODD protocol [7] is a protocol originally formulated by ecologists that aims at providing a standard layout for describing individual and agent-based simulation models. It especially aims at document ABM for scientific publication and consists of several building blocks that facilitate writing and reading of model descriptions, using natural language. It is not a formal description aiming at being read by machine nor at being directly compiled to computer code. It is then still subject to ambiguity. The acceptance of ODD among social simulation community has been slow.

Another interesting initiative is the OpenABM (http://openabm.org), a repository of ABM contributed by users. OpenABM website is a portal specifically designed to facilitate the dissemination of simulation code, where contributors are required to upload the simulation code and describe the models using the ODD protocol. It has now grown to an cyber infrastructure to preserve computational models and their digital context on agent based modelling with about 500 models, at the time of this publication. The sharing of models and computacional code certainly contributes facilitate models replication and validation. Nonetheless, the link between a model description with ODD and the respective simulation code is not verified and each user would need the programming skills to verify if description conforms to implementation.

Provenance in agent-based simulations is another way of tackling the specification of ABM. Provenance, which is a type of metadata, is the lineage of a data product or process: it's creator, contributing processes, interactions, and data sources. In the context of agent based modelling, provenance captures state changes in individual agents and interactions through time [4]. In [8], authors investigated the role of provenance and proposed to record tree types of provenance about a simulation: about the social process of model development, about the execution of a model and about the history of a simulation. Authors concluded that as the number of simulation runs and agents in the simulation increases, these queries become exponentially complex and the application to more complicated model might be challenging.

3 A framework for the Specification of Agent-Based Models in socio-spatial systems

We believe that it should be possible to relate a model description (e.g with ODD) to a simulation code. Many ABM practitioners are not computer scientists who can write and read computer programs. We think that this gap between description and implementation remains a challenge for many ABM users. To address this question we propose to adopt a research approach consisting in the development of a Domain Specific Modelling Language (DSML). DSML are specification languages that offer, through appropriate notations and abstractions, expressive power focused on, and usually restricted to, particular problem

domains [6]. On the other hand, in computing, linked data describes a method of publishing structured data so that it can be interlinked and become more useful through semantic queries. It builds upon standard Web technologies such as HTTP, RDF and URIs, but rather than using them to serve web pages for human readers, it extends them to share information in a way that can be read automatically by computers. Using ODD as a domain model, we aim at using it to compare the executable systems (source code for simulation) and the model description, in order to verify the conformity between both artefacts. Using this DSML, we could represent the model instances from the code as linked data and compare it to ODD representation and vis-versa.

4 Conclusions

In this paper, we present the importance of agent-based model documentation and the challenge for practitioners to verify its conformity to models implementations. We identified that a gap between system representation and system implementation still exist for modellers, which represents a limitation to ABM communication and replication. Our goal is to provide a modelling language that would meet users needs and that would be straightforward enough to be adopted by the main users of the domain. We aim at presenting the first steps toward the development of this modelling language.

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